The Search for a Planetary Ocean on Europa

Frank Carsey on a ship in the ice-covered Labrador Sea.

Hello I am Frank Carsey of Caltech's Jet Propulsion Laboratory. My research specialty for the past 20 years has been ice-covered oceans in the Earth's polar regions, but now I am doing something new. I am studying a lake that is beneath 3.7 km (about 2 1/4 miles) of ice in Antarctica [Fig. 1] and looking at its similarities with Europa [Fig. 2]. Europa is a moon of Jupiter that has an icy outer crust which is about 200 km (120 mi) thick. We think that Europa may have a liquid ocean beneath a rather thin ice cover such that the total ice + water layer is 200 km thick. On the other hand it may be that there is no liquid now, but that there was an ocean there in astronomically recent time, that is, a few million years ago [Fig 3].

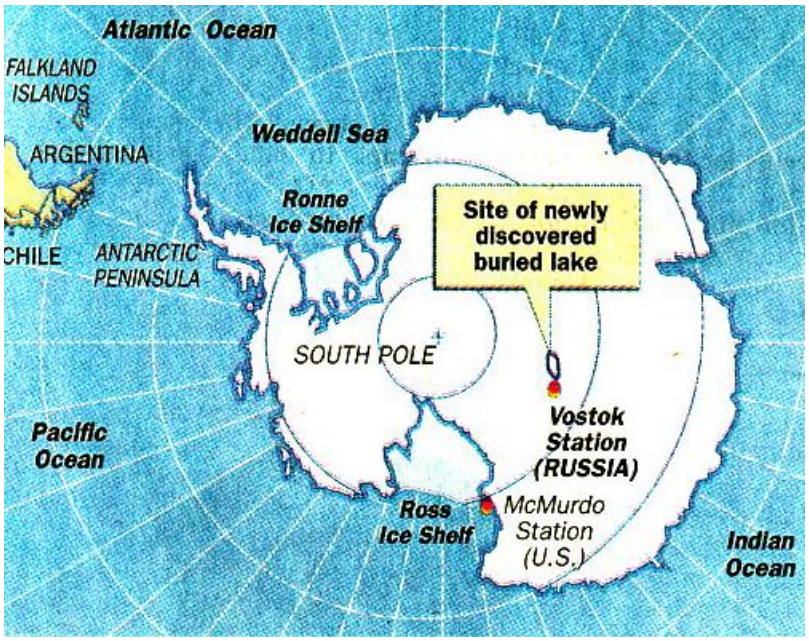

Figure 1. Location of Lake Vostok within the Antarctic.

Europa

The Europan ocean, if there is one, will be amazing. It may be larger in volume than Earth's ocean and possibly 20 times as deep. Since this ocean would probably have existed for more than a billion years, it may contain life forms of some sort, probably microscopic. In addition, the formation and evolution of Europa is intriguing; it is

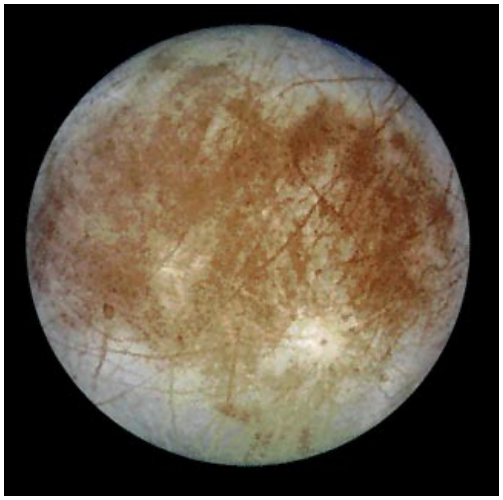

Figure 2. Europa as imaged by Voyager.

Figure 3. View of a small region of the thin disrupted ice crust in the Conamara region of Europa, as imaged by the spacecraft Galileo. The smallest features you can see are about 100 feet across.

unique in the solar system. Europa is scientifically very interesting to explore, but this exploration would be robotic and not involve humans for some time as the surface of Europa is about -250°C, at near vacuum pressures, and under intense radiation bombardment from Jupiter.... not a vacation destination!

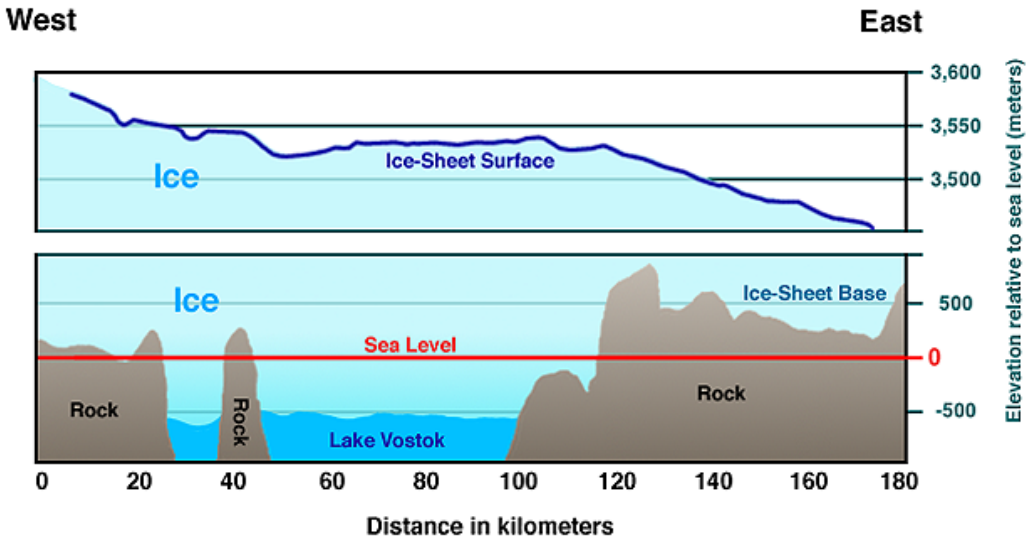

Figure 4. Profile of Lake Vostok produced from echo sounding, taken from A.P. Kapistsa et al.

Lake Vostok

Lake Vostok is a very large lake under the Antarctic ice sheet. It was discovered in the 1960s, but its true size was understood only a few years ago. It is the area of Lake Ontario and 3-4 times deeper. The deepest part of the lake is thought to be about 850 m (2,800 feet) deep, and it has about 125 m (412 feet) of sediment, or mud, at the bottom [Fig. 4]. It may be the third largest lake in the world [Fig. 5]. However, we know almost nothing about the Lake Vostok's biota, water chemistry, currents, or temperatures.

The history of the Lake Vostok is a fascinating mystery. Some people think it has been a fresh-water lake for over 30 million years, that is, since the time before Antarctica had an ice cover, during a time that geologists call the Oligocene. If so the lake would have had a full selection of Oligocene lake biota, from fish to bacteria. Some of these creatures, most likely the bacteria, probably adapted to the changing conditions and survived to the present. Other people think that the lake formed about 10 million years ago. If this is the case the biology in the lake would be quite different as only a very few bacteria and spores from melted ice above the lake would be available to populate the lake; and we have no idea what biota

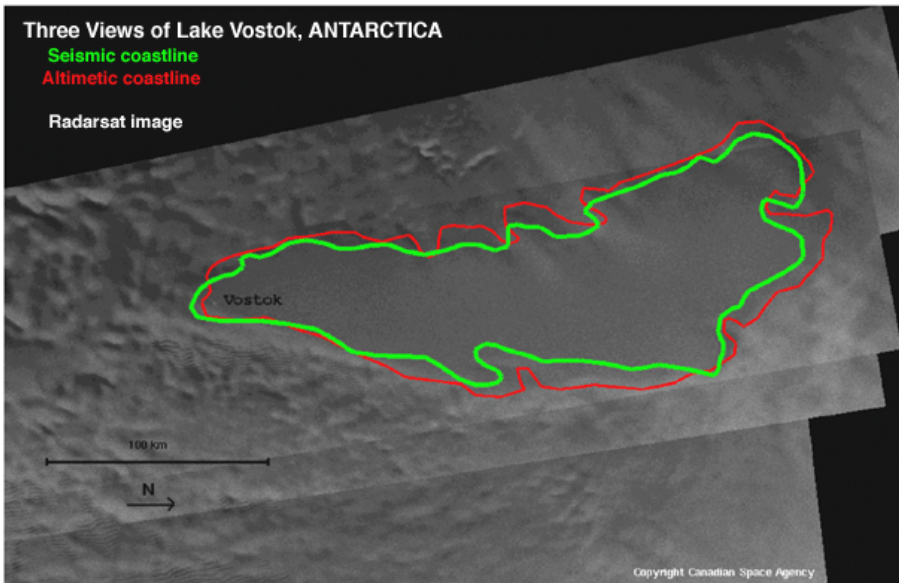

Figure 5. This is a radar image of the ice covering Lake Vostok and the surrounding area. The image was taken by the RADASAT earth-orbiting satellite. The ice over the lake is smooth. The two outlines are taken from two previous studies of the lake using different types of data. We are still working to understand what happens as the ice moves slowly from west to east over the lake at a rate of about 2 meters per year.

evolved under these conditions. The sediments are also of great interest. They probably hold the key to the geologic history of that part of Antarctica, about which we know almost nothing.

Science

We want to explore the ice, water and sediments to obtain basic information about Lake Vostok and Europa. We want to understand:

1 Life within the water, sediment, and ice cover
2 Characteristics of the water, sediment, and ice habitats; that is, the ability of these sites to support life of some sort.
3 History and development phases of the two places, Europa and Lake Vostok, with respect to how the ice, water, and rocky core have evolved and interacted over the past millions to billions of years.

This is a demanding effort. At Lake Vostok we need to take scientific instruments through about 2 miles of ice into a cold, dark lake, without contaminating the lake. At Europa, we need to take instruments through unknown amounts of ice and into an enormous ocean [Fig. 6]. But first we have the challenge of getting the instruments from here to Europa! Once there, contamination prevention is crucial, as any life forms taken there from Earth might multiply dramatically and catastrophically and erase our chance of seeing the Europan form of life.

We have started by designing vehicles, one to melt down through the ice (called a Cryobot) and one to move about in the water (called a Hydrobot). Cryobots, also called thermal probes [Fig. 7], have been used on Earth's ice sheets in Greenland and Antarctica, and our goal is to build them with new, highly specialised, miniaturized instruments, known as microdevices. Hydrobots, also called submersibles, have been used extensively in oceans for sunken ship exploration and even inspection of large water systems. Our goal is to build tiny submersibles, again with microdevices, which can operate autonomously,

Figure 6. Artist's concept of the cryobot and hydrobot. These robots are in the very initial stages of design and may look very different as the robot design evolves.

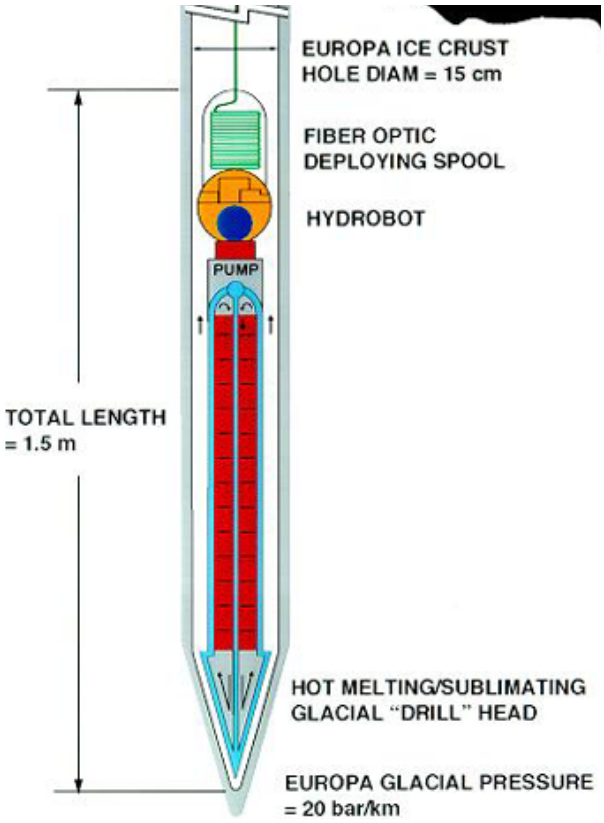

Figure 7. The cryobot as it is currently planned. Over the next few years the design will evolve as people develop new instruments for it to carry. Electricity, supplied from the surface, will be the power source for melting.

that is, without having a person operating them. We also need to design and build the microdevices, which include cameras and chemical sensors, to obtain the data we need to understand these environments and the life forms they may contain.

The Lake Vostok/Europa project is complex. It involves specialists in ice drilling, ice chemistry, instruments, biology, decontamination, and space science. As a result, we are working with a large number of people in different parts of the world. It will be very exciting exploring these new frontiers, developing new equipment, and working with experts in many different fields.